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ABSTRACT

This module was developed to help those who train elementary teachers to increase the awareness of preservice elementary school teachers of the effects of sex role stereotypes as they pertain to womens' achievement in mathematics. The topics covered include: (1) career implications of mathematics; (2) counteracting the stereotypes; (3) encouraging the development of spatial ability; and (4) mathematics anxiety. Worksheets are included in the appendix. (MP)

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Facilitating Sex-Fair Teacher Training: A Module for Inclusion in an Elementary Mathematics Methods Course

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Introduction

> "Today, more than ever before, the study and appreciation of mathematics are vital to the intellectual development and to the scientific, industrial, technological, and social progress of society. It is essential that teachers, counselors, supervisors, educational administrators, parents, and the general public work together to provide the best mathematics education possible for all students, regardless of sex..."
>
> NCTM Statement in Counseling
> May, 1976

Those who train teachers and those who teach elementary students can have a favorable impact on reducing the perception that mathematics is a masculine subject. However this cannot be left to chance. Many teachers are products of their own socialization and believe that boys have more potential as math students (Ernest, 1974), that even very bright girls will find mathematics a difficult subject, and that success in mathematical endeavors is not appropriate and should not be rewarded for females (Levine, 1976). If change is to occur teachers will have to clarify their own beliefs with regard to mathematics. Then they will be ready to help young people become aware of and to overcome the stereotypes surrounding mathematics. The following modules were developed to help those who train elementary teachers. The modules are designed to increase the awareness of pre-service elementary school teachers of the effects of sex role stereotypes as they pertain to womens' achievement in mathematics.

Objectives

By the completion of this module:

1. the student will be able to explain the mathematical background necessary for at least 20 career areas.

2. the student will be aware of sex role stereotypes and how they affect the mathematical ability of females.

3. the student will be able to define visual-spatial ability, explain its relationship to job skills, and be able to list at least five intervention strategies which foster the development of spatial ability in elementary age students.

4. the student will have participated in at least three strategies designed to reduce math anxiety.

I. Career Implication of Mathematics

Class time required: approximately 2 hours

Rationale:

Forty percent of the American work force is female. Of the young women now in school, over ninety percent will work outside the home for some portion of their life. Those who marry will work an average of 25 years. Those who remain single will work an average of 45 years. At least thirteen percent of American families are headed by women. According to ETS statistics, in 1975 a male high school graduate earned approximately the same salary as a female college graduate. A woman's salary is 55% of that of a similarly-educated male.

The study of mathematics is vital to the career progress of individuals regardless of sex. Non-required courses on this subject, however, are underpopulated by females. Many educators are beginning to seek remedies for this condition.

Research supports the folk-knowledge that in the elementary school years girls do at least as well as boys in all subjects, including mathematics. However, during the secondary school years, young women do not achieve as well as young men in the study of mathematics (Maccoby and Jacklin, 1974; Callahan and Glennon, 1975; Mullis, 1975; Fox, 1976). In 1976, although a heartening 6,509, or forty percent, of bachelor's degrees in mathematics were awarded to women (Grant, 1978), female students earned only 2.2% of the degrees in engineering (Eiden, 1976) and were grossly underrepresented in fields such as the natural sciences and economics which use mathematics as a tool (Ernest, 1976). A study which included all students with declared majors on seven of the campuses of the University of California revealed a highly significant ($p < .0001$) difference in course-taking behavior by sex. Thirty-two percent of the variance in female representation in major fields was accounted for by the number of pre-requisite mathematics courses (Hedges and Majer, 1976).

Male students believe that mathematics will have career relevance. Female students are not as convinced that this is the case (Hilton and Berglund, 1974; Ernest, 1976). Those not interested in mathematics or science as a career may not recognize that one needs mathematics in careers such as teaching or the social sciences.

Mathematics is an equally important subject for those who do not wish to go to college. Many of the technical trades such as carpentry and brick laying demand mathematical skills. By taking several mathematics courses in high school, the non-college-bound student also keeps a maximum of career options available. Elementary teachers who inform their students of these facts do them a real service.

Career choices often crystallize during the junior high school years (Borow, 1966); it is crucial that students be alerted to the importance of mathematics for a wide range of vocations in the later years of elementary school. This section of the module contains some steps mathematics educators can take in methods courses to raise the awareness of pre-service elementary school teachers to the career relevance of mathematics.

1. Sources of Information Regarding the Career Relevance of Mathematics

To alert students in the later elementary years to the career relevance of mathematics, pre-service teachers should be encouraged to collect literature on mathematics-dependent careers for display in their classrooms. Secondly, a list of speakers on careers for which mathematics is essential should be compiled as a class project. One helpful source for both materials and speakers is the program sponsored by the Mathematics Association of America called Women and Mathematics (WAM). WAM, directed by Dr. Eileen Poiani of St. Peter's College, Jersey City, New Jersey, is funded by IBM and maintains a list of women speakers from a variety of fields who will

address students on the importance of continuing the study of mathematics in high school.

Role models are powerful influences on human behavior (Plost and Rosen, 1974; Casserly, 1975; Levine, 1976). Among strategies used to increase women's participation in mathematics and science, the presence of role models may be the most effective (Fox, 1976). Early exposure to adults who lead satisfying lives both as women and as professionals in mathematics-dependent careers will provide proof of the appropriateness of any career for females as well as males (Westervelt, 1975). Guest speakers on scientific topics do not have to be men and if women, should not be introducted as curiosities! Pre-service teachers who are sensitive to the psychological impact of role models should consider this dimension in their choice of classroom guests.

Two free booklets, "Careers for Women in Mathematics", and "Math in High School You'll Need for College", may be obtained by writing to MAA, 1225 Connecticut Avenue, NW, Washington, DC 20036. These booklets explain that at least three years of high school mathematics are required for entrance into engineering, science and mathematics majors in most colleges. Even for entrance into the social and behavioral sciences, long the haven of the math-wary, mathematics is now required. Those who fail to take sufficient mathematics in high school at best delay their entrance into most college majors. Those who have avoided taking mathematics in high school are also the least likely to elect it in college. The booklet "Math in High School You'll Need for College" delineates clearly just which careers are mathematics-dependent and the magnitude of that dependence.

The counseling literature contains many excellent articles on providing sex-fair counseling to young men and women. Verheyden-Hilliard's recent discussion in American Education is especially relevant. Another useful

reference is the Handbook on Sex Equality in the Schools, an outgrowth of the Sex Equality in Guidance workshops. This reference is available through the American Personnel and Guidance Association and it would be a valuable addition to any educator's reference library. Aware counselors can be excellent allies to classroom teachers who seek to alert students to the financial and academic opportunities available to them. The counselors at the local secondary school may allow elementary students to attend career days or to hear special speakers. They may also have material describing mathematics-related careers that they will share.

Books such as Splaver's Non-traditional Careers for Women or Mitchell's I Can Be Anything: Colleges and Careers for Young Women can increase the awareness of the career relevance of mathematics in pre-service elementary school teachers. These books may also become a resource for upper elementary school pupils. College instructors have a unique opportunity to alert future elementary teachers to the importance of a real "bread and butter" issue which can have a major effect on their pupils' futures.

2. Two projects for raising awareness

Receiving information will not in itself change behavior, but active involvement of students in data-gathering is likely to increase the impact of information. Two projects which will involve students in a consciousness-raising exercise designed to highlight the importance of mathematics and which are applicable in the elementary classroom are interviewing and collage-making.

Interviewing

Ask students to interview at least four people on ways they use mathematics in their careers. Such an activity blends mathematics and language arts as the students develop question sets, conduct the survey, record the responses and write up the results. Share the results of these interviews

in class and compile a class list of the career areas that need mathematical skills.

Collage-making

In a second activity students make a collage. From pictures in magazines, newspaper headlines and self-drawn illustrations, have students construct a collage of the ways mathematics is used in today's world. Include on the job and in the home uses.

For Further Reading

Borow, Henry. Development of occupational motives and roles. In L. W. Hoffman and M. L. Hoffman (Eds.) Review of Child Development Research, Vol. II, New York: Russell Sage, 1966.

Callahan, Leroy G. and Glennon, Vincent J. Elementary School Mathematics: A Guide to Current Research, Fourth Edition. Washington, DC: Association for Supervision and Curriculum Development, 1975.

Casserly, Patricia L. An Assessment of Factors Affecting Female Participation in Advanced Placement Programs in Mathematics, Chemistry, and Physics. Princeton: Educational Testing Service, 1975.

Eiden, Leo J. Trends in female degree recipients. American Education, 1976, 12, back cover.

Ernest, John. Mathematics and Sex. Santa Barbara: University of California, 1976.

Fox, Lynn H.; Pasternak, Sara R.; and Peiser, Nancy L. Career-related interests of adolescents. In Daniel P. Keating (Ed.) Intellectual Talent: Research and Development. Baltimore: Johns Hopkins Press, 1976.

Goldman, Roy D.; Kaplan, Robert M. and Platt, Bruce B. Sex differences in the relationship of attitudes toward technology to choice of field of study. Journal of Consulting Psychology, 1973, 20, 412-418.

Grant, Vance. Statistical Information Branch, National Center for Education Statistics. Personal Communication, May 9, 1978.

Hedges, Larry V. and Majer, Kenneth. Female and minority representation in college majors as a function of mathematics requirements. La Jolla: University of California at San Diego, 1976. ERIC document 123979.

Helson, Ravenna. Women mathematicians and the creative personality. Journal of Consulting and Clinical Psychology, 1971, 34, 210-220.

Hilton, Thomas L. and Berglund, Gosta W. Sex differences in mathematics achievement -- A longitudinal study. Journal of Educational Research, 1974, 67, 231-237.

Levine, Maita. Identification of Reasons Why Qualified Women Do Not Pursue Mathematical Careers. Washington, DC: National Science Foundation, 1976.

Luchins, Edith H. Women in Mathematics: Problems of Orientation and Reorientation. New York: Reneselear Polytechnical Institute, 1976.

Mitchell, J. S. I Can Be Anything: Careers and Colleges for Young Women. New York: College Entrance Examination Board, 1975.

Mullis, Ina V. S. Educational Achievement and Sex Discrimination. Denver, Colorado: National Assessment of Educational Progress, 1975.

Osen, Lynn. Women in Mathematics. Cambridge: MIT Press, 1974.

Plost, Myrna and Rosen, Marvin J. Effects of sex of career models on occupational preferences of adolescents. AV Communication Review, 1974, 22, 41-50.

Splaver, Susan. Non-traditional Careers for Women. New York: Julian Messner, 1973.

Verheyden-Hilliard, Mary Ellen. A Handbook for Workshops on Sex-equality in Education. Washington, DC: American Personnel and Guidance Association, 1976.

_____. Counseling: Potential superbomb against sexism. American Education. 1977, 13, 12-15.

Westervelt, Esther M. Barriers to Women's Participation in Postsecondary Education. Washington, DC: Department of Health, Education, and Welfare, 1975.

II. Counteracting the Stereotype

Class time required: approximately 1 hour

Rationale:

> Even at an early age, boys are expected to be interested in mathematics. Girls, on the other hand, though they may have equal ability, may be discouraged from learning by the prevailing idea that mathematics is a masculine field (Lambert, 1960, p. 19).

> This actual difference (in mathematics achievement of boys and girls), we believe, should be put down to the widespread view of professions as masculine or feminine. The result is that mathematics is often outside the sphere of girls' interests. At least, we have no data available today that would compel us to draw a different conclusion (Krutetskii, 1976, p. 343).

> Parents who would suffer keen mortification if the boy for whose education they are responsible were in danger of being rejected by his college because of his failure in required mathematics will condone any shortcomings of the girl in that line with a deprecating "You know that one does not think so much of a failure in mathematics for a girl" (Martin, 1917, p. 396).

From age nine upwards, males outperform females on tests of mathematics achievement. Research on sex differences provides little justification for this phenomenon. For example, mathematical ability correlates highly with general intelligence in which no consistent sex differences have been found. Mathematical ability also correlates with deductive reasoning (in which there are no consistent sex differences), verbal abilities (sex differences in favor of females are often found), and spatial ability (in which sex differences favoring males appear during, but not before, adolescence). Tests on Piagetian test also fail to yeild consistent sex differences during the elementary school years (Maccoby and Jacklin, 1974; Armstrong, 1975).

How, then, can one account for the differences in achievement between males and females in mathematics? One answer may be that in this country and elsewhere, mathematics is considered a males domain. Males are expected to have a higher

potential for understanding an achievement in mathematics. Given the universality of this belief, is it any wonder that males excel? They are living up to the cultural expectations. In effect, the belief in male superiority in mathematics has become a prophesy fulfilled.

1. Evidence of the Existence of the Stereotype

Parents play a major role in developing or hindering the later mathematical progress of their daughters (Casserly, 1975). Ravenna Helson, in a 1971 study of women mathematicians, found that almost every one of them had grown up in homes where parents had a strong respect for learning and achievement and had rewarded their daughters for intellectual successes. Osen (1974) reports a similar finding in a history of women in mathematics.

As important as parental attitudes and expectations may be, the pressure of peers may be even more influential. Young women who excel in the study of mathematics receive less attention from their male peers (Luchins, 1976) and are often uncomfortable in social relationships with them (Fox, 1976). Mrs. Helen Andelin, mother of eight and author of Fascinating Womanhood and The Fascinating Girl, speaks directly to young women who might be tempted to fulfill their own intellectual interests without considering the possible effects on the men around them:

> Don't compete with [men] for scholastic honors in men's subjects. It may be all right for you to win over a man in English or Social Studies, but you are in trouble if you compete with him in math, chemistry, public speaking, etc. Men may admire women who excel in them but they are not apt to ask them for a date. Why? Because they have defeated them in their own field (Andelin, 1970, p. 164).

One of the saddest facts about this quotation is that it is often true. In a study of 350 women mathematicians, Luchins (1976) found that not only had almost half of them been discouraged by teachers and by peers on the grounds that "boys wouldn't like them", but that these women received less

positive attention from men as they advanced to higher levels.

> In almost any age, it has taken a passionate determination as well as a certain insouciance, for a female to circumvent the crippling prohibitions against education for women, particularly in a field that is considered to be a male province. In mathematics the wonder is not that so few have attained proficiency in the fields, but that so many have overcome the obstacles to doing so. We can only speculate about the multitude who were dissuaded from the attempt (Osen, 1974, p. 163).

Contemporary female mathematicians reported that they had equally distressing experiences. One professor of mathematics stated that in elementary school she had been discouraged from skipping a grade because she probably wouldn't be able to learn long division. When, as an undergraduate, another professor won an award in a competitive mathematics examination, she was told that "girls weren't supposed to get the prize". A third mathematician indicated that at her university women graduates were recommended for jobs only at women's colleges and that only certain professors were "willing to take on girls" (Levine, 1976). Society has even been known to reward female incompetence in this area. A 1975 advertisement, for example, used this approach:

> You might as well give her a grogeous pen to keep her checkbook unbalanced with. A sleek and shining pen will make her feel prettier, which is more important to any girl than solving mathematical mysteries.

In research conducted with 140 elementary teachers, Gregory (1977) found that in every case, boys described as having difficulty in mathematics were more likely to be referred than girls. Indeed, the difference in referral was significant at the .023 level. The teachers in the study had received a set of five anecdotes describing children with school-related problems and were asked to state whether they would or would not refer each child. There was no limit on the number of children they could refer. In every case, boys were more likely to be referred.

A brief sampling from the attached bibliography will convince the most unaware mathematics method student that the stereotype of mathematics as a masculine domain is alive and well today. Becoming aware of the existence of a stereotype is the first step in eradicating it. Following are some suggestions for classroom activities that will increase students' awareness of the pervasiveness of sex role stereotypes in the classroom generally and in the mathematics curriculum, specifically.

2. Techniques to Counteract the Stereotype

Stereotypes need not always be confronted "head on". Indeed that is often an ineffective technique. In this section of the module some non-"preachy" suggestions for counteracting the stereotype of mathematics as a male domain are given.

One way to expose pre-service students to the literature of mathematics education is to have them write a position paper on a currently controversial topic. Among the issues math methods instructors might offer for consideration are "Back to the Basics!", "Mathematics is a Masculine Domain", "Calculators Belong in Every Classroom" and "Drill is Worthless". If it seems prudent, instructors might devote some class time to open discussion of these topics so students can share their discoveries and opinions.

A second technique involves the use of an observation scale in the classroom. An observation scale can direct the students' attention towards the differential treatment warded students based on their gender membership. By such a means, students become aware of the hidden messages abounding in the classroom. For example, does the teacher always ask girls to dust or to water the plants and boys to collect books and to move equipment. The authors have developed an instrument to be used for this purpose. (See Appendix A)

Finally, a values clarification technique called rank ordering can simultaneously enliven a methods class and shed light on some stereotypic notions

unconsciously held by future teachers. In this exercise, participants are asked to listen to a situation and to place in order of preference the three choices presented. All alternatives must be ranked from the most acceptable to the least acceptable; none may be omitted. Consider following situation:

> Your district has just established an accelerated program for students gifted in mathematics. Enrollment will be very limited. In what order would you refer these three equally gifted students? The likelihood of their participation decreases as their position on the list is lowered:
> a. a deeply religious boy whose religion strongly encourages large families
> b. a boy whose vision is very poor and who is expected to go blind before he is 20
> c. a boy who is sullen and rude and does not study

Having completed that ranking, consider this situation:

> Your district has just established an accelerated program for students gifted in mathematics. Enrollment will be very limited. In which order would you refer these three equally gifted students for the program? The likelihood of their participation decreases as their position on the list is lowered:
> a. a deeply religious girl whose religion encourages large families
> b. a girl whose vision is very poor and who is expected to go blind before she is 20
> c. a girl who is sullen and rude and does not study

After the students have completed both rankings, a classroom discussion on the reasons for their choices should take place. The differences in ordering will illuminate many underlying assumptions which form the basis for decisions in the real world. For a particularly difficult task, have students rank order all six of the candidates for the special class.

Another values clarification exercise which may be used is a forced choice exercise. For this activity, a situation in which equally attractive (or repulsive) alternatives are described, participants are asked to choose one alternative. Abstention is not allowed. Alternatives do not have to be publically shared, but the individual must come to a decision as to which

alternative will be chosen. An example of a forced choice situation:

> You can refer children from your elementary classroom in each of the five categories named. Only one child can be referred for each of the five. Would you refer a boy or a girl whom you believe equally in need of special help?
> a. the child is withdrawn
> b. the child is gifted but has a mild behavior problem
> c. the child has reading difficulties
> d. the child cannot grasp arithmetic concepts at all
> e. the child is aggressive

Once each person has reached his or her decision, you may wish to compare the findings with those of Gregory (1977), as reported in the first section of this module.

Stereotypes are not easy to dispel. However, mathematics educators who are themselves models of non-stereotypic behavior and who encourage sex-fair thinking in their students will do much to counteract the prevalent assumption that mathematics is "For Men Only".

For Further Reading

Andelin, Helen B. The Fascinating Girl. Santa Barbara: Pacific Press, 1970.

Armstrong, Jenny R. Factors in intelligence and mathematical ability which may account for differences in mathematics achievement between the sexes. In Elizabeth Fennema (Ed.) Mathematics Learning: What Research Says About Sex Differences. Columbus, Ohio: ERIC Center for Science, Mathematics and Environmental Education, 1975.

Burton, Grace M. Regardless of sex. The Mathematics Teacher, 1978, in press.

Casserly, Patricia L. An Assessment of Factors Affecting Female Participation in Advanced Placement Programs in Mathematics, Chemistry and Physics. Princeton: Educational Testing Service, 1975.

Conference Board of the Mathematical Sciences. Overview and Analysis of School Mathematics, Grades K-12. Washington, DC: National Science Foundation, 1975.

Ernest, John. Mathematics and Sex. Santa Barbara: University of California, 1976.

Fennema, Elizabeth and Sherman, Julia. Sex-related differences in mathematics achievement, spatial visualization and affective factors. American Educational Research Journal, 1977, 14, 51-71.

Fox, Lynn. The Effects of Sex Role Socialization on Mathematics Participation and Achievement. Washington, DC: National Institute of Education, Education and Work Group, 1976.

Gregory, Mary K. Sex bias in school referrals. Journal of School Psychology, 1977, 15, 5-8.

Helson, Ravenna. Women mathematicians and the creative personality. Journal of Consulting and Clinical Psychology, 1971, 34, 210-220.

Jay, Winifred T. and Schminke, Clarence W. Sex bias in elementary school mathematics texts. The Arithmetic Teacher, 1975, 23, 242-246.

Keeves, John. Differences between the sixes in mathematics and science courses. International Review of Education, 1973, 19, 47-63.

Kepner, Henry S., Jr., and Koehn, Lilane R. Sex roles in mathematics: A study of the status of sex stereotypes in elementary mathematics texts. The Arithemetic Teacher, 1977, 24, 379-384.

Krutetskii, V.A. The Psychology of Mathematical Abilities in School Children. Chicago: The University of Chicago Press, 1976.

Lambert, Philip. Mathematical ability and masculinity. The Arithemetic Teacher, 1960, 7, 19-21.

Levine, Maita. Identification of Reasons Why Qualified Women do Not Pursue Mathematical Careers. Washington, DC: National Science Foundation, 1976.

Luchins, Edith H. Women in Mathematics: Problems of Orientation and Reorientation. New York: Reneselear Polytechnical Institute, 1976.

Maccoby, Eleanor E. and Jackoin, Carol. The Psychology of Sex Differences. Stanford: Stanford University Press, 1974.

Martin, Emilie N. Relating to required mathematics for women students. American Mathematical Monthly, 1917, 24, 394-398.

Milnar, Josephine. Sex stereotypes in mathematics and science textbooks for elementary and junior high schools. In Diane Gersoni-Stavn (Ed.) Sexism and Youth. New York: R. R. Bowker, 1974.

Oakley, Anne. Sex, Gender and Society. New York: Harper Colophon Books, 1972.

Osen, Lynn. Women in Mathematics. Cambridge: MIT Press, 1974.

Rogers, Margaret Anne. A different look at word problems. The Mathematics Teacher, 1975, 68, 285-288.

III. Encouraging the Development of Spatial Ability

Class time required: approximately 2 hours

Rationale:

There have long been those who have asserted that men are superior to women in certain intellectual areas simply because they were male. Until the twentieth century, this superiority was taken for granted as part of God's design for the human race. The lack of co-educational facilities coupled with the lack of standardized testing procedures hampered research on this question.

While few believe that mathematical ability is the sole province of the male sex, there may be biological reasons for male superiority in <u>one</u> facet of mathematical ability -- that of spatial visualization. Spatial visualization includes the ability to rotate shapes in the mind and to orient oneself or other objects in space. It also includes the ability to recognize an object from different perspectives. These abilities may be of importance in solving problems in certain areas of mathematics (geometry, for example). Even in spatially-related content strands, lack of spatial ability can be compensated for by verbal ability. Two people who solve a geometric problem, for instance, may utilize different strategies -- one abstracting relationships through a visual mode, the other "talking the problem through".

1. Spatial Ability: Is It Important?

Currently there are three biological reasons advanced to explain the differences in spatial ability between the sexes -- one is based on a theory of a recessive gene on the x-chromosone which enhances spatial ability in about half the male and one quarter of the female population. A second biological argument theorizes that male sex hormones play a role in enhancing spatial ability. A third theory concerns differences in the brain lateralization process. Sex-related differences in maturation rate have also been profferred as an explanation for the difference. Precise accounting for male superiority

in spatial ability is not yet available.

Whatever potential for spatial ability exists in a given individual, it can either be encouraged or discouraged. For many young women, the latter course is unintentially followed.

Sex-appropriate activities are fostered both consciously and unconsciously by parents, peers, and teachers. Toy selection is one highly visible indication of this practice. By the age of three, boys and girls are aware of which are boys' toys and which are girls' toys and tend to play with sex-appropriate toys. Play with feminine toys has been shown to be negatively correlated with field independence. And field independence, in turn, has been found to be highly correlated with success on visual-spatial tasks. On the other hand, engaging in male play patterns correlates highly with field independence and high spatial ability for young girls.

Adults use spatial skills in a wide variety of everyday settings, from parking a car to planning a new kitchen. Such skills are important in occupations as divergent as dressmaking, architecture, and surgery.

The career relevance of spatial skills is readily apparent in a profession such as drafting. Drawings of the front view, side view, and top view of an object make immediate sense to those who have spatial ability. A lengthy logical process must be undertaken by those who lack it before they are convinced that the same object is depicted in all three illustrations. Drafting, a highly-paid, skilled trade would be an excellent career choice for non-college bound women with the requisite spatial skills. For the college-bound student fields such as engineering and design similarly offer rewarding career possibilities and depend on spatial ability.

As spatial skills are important in a variety of exciting careers, each child's potential in this area should be developed to the maximum possible level. Those who work with children will, by providing opportunities for

practice in spatial skills, help such development take place. Those who work with future teachers should convince them of the importance of enhancing spatial ability in children. In this module several techniques for encouraging the development of spatial ability will be discussed.

2. Techniques which Encourage the Development of Spatial Ability

Many materials and activities encourage the development of spatial ability. Several of these are: building with a variety of elements from giant hollow blocks to Lincoln Logs, Tinker Toys, Legos and Erector Sets; engaging in sand and water play; and climbing on a jungle gym or running across a field. All are easily made part of the child's early school experiences. Positive encouragement from teachers will insure that girls, as well as boys, participate in and profit from these activities.

Strategies which encourage the development of spatial ability can become a part of many elementary curriculum areas as well. Physical education classes can be especially enriching. For younger children, the many body-awareness games are an important basic step. Games which involve throwing balls and catching them, for example, develop spatial skills as well as large and small muscles and coordination. They should be part of the physical education program for both boys and girls.

Art projects can also play an important role in the development of spatial ability. Constructing mobiles and creating symmetric designs are two such projects which are easy to implement. In a more mathematical vein, string art, an outgrowth of curve stitching, provides much practice in spatial visualization. A unit on Japan can easily include a day's experimentation with origami.

Within the mathematics curriculum two topics -- tangrams and map-and-compass work -- are especially related to spatial ability. Exercises in these two areas are easily adapted to a wide range of ability, and will

provide balance to a curriculum overly-arithmetical in nature. A search for geometric shapes in the environment and a unit on estimation of distance and capacity will serve a similar function.

Elementary teachers who are aware of the importance of spatial skills can incorporate into the curriculum many strategies which foster their development. Instructors of mathematics methods courses who are aware of the importance of spatial skills can incorporate into their courses many topics which will help future teachers enrich the mathematics curriculum for children. The references which follow will be useful for both sets of educators.

For Further Reading

Astin, Helen. Sex differences in mathematical and scientific precocity. Journal of Special Education, 1975, 9, 79-92.

Coates, Susan, Mae Lord, and Evelyn Jakobovics. Field dependence-independence, social-non-social play and sex differences in preschool children. Perceptual and Motor Skills, 1975, 40, 195-202.

Eliot, John and Jacqueline S. Fralley. Sex differences in spatial abilities. Young Children, 1976, 31, 487-499.

Eliot, John and Neil J. Salkind. Children's Spatial Ability. Springfield, Illinois: Charles C. Thomas, 1975.

Johnson, Donovan A. Paper Folding for the Mathematics Class. Washington, DC: NCTM, 1957.

Knowles, Evelyn. Fun with one-to-one correspondence. The Arithmetic Teacher, 1965, 12, 370-372.

Maccoby, Eleanor and Carol N. Jacklin. The Psychology of Sex Differences. Stanford: Stanford University Press, 1974.

Randlett, Samuel. The Art of Origami: Paper Folding, Traditional and Modern. New York: E. P. Dutton, and Co., 1961.

Read, Ronald C. Tangrams: 330 Puzzles. New York: Dover Publications, 1965.

Seymour, Dale, Linda Silvey and Joyce Snider. Line Designs. Palo Alto: Creative Publications, 1968.

Sherman, Julia A. Effects of Biological Factors on Sex-related Differences in Mathematical Achievement. Washington, DC: National Institute of Education, Education and Work Group, 1977.

IV. Math Anxiety

Class time required: approximately 3 hours

Rationale:

Many teachers are familiar with an unpleasant condition characterized by sweating palms, nausea, shortness of breath and pale cheeks. The name of the malady -- math anxiety. Both women and men suffer from math anxiety, although men find it more difficult to admit they are victims. The math anxious tend to avoid mathematics in any of its guises from courses in tests and measurement to balancing a checkbook, and predictably, they continue to remain uncomfortable when they must use or teach mathematics. Often teachers pass the anxiety on to their students.

Neither reviewing the fundamentals of mathematics nor introducing exciting games and attractive manipulative devices is sufficient to erradicate math anxiety. However, some general techniques do seem to be helpful in lessening its intensity.

First, build an atmosphere in which students are not afraid to ask "dumb questions". While it may be annoying to discover that an adult really doesn't understand why the division algorithm "works", expressing that annoyance will help no one. Encourage questions that will lead to explanations of "why" and "how". Many people have never had the opportunity to ask questions of someone who both knew the answer and was willing to explain. Be that someone for them.

Second, don't be afraid to talk about your own mathematical difficulties. Math anxious people often say they don't have a "math mind". Many math educators have known first-hand the frustration of word problems that just didn't make sense, of long division papers smudgy with erasures, and of geometric "proofs" that led nowhere. Share your experiences, if you can.

Third, teach mathematical content by using methods that students will be able to use in their classroom. Use concrete materials whenever possible. Most

students will be more willing to attempt mathematics if it is presented in a novel and non-threatening way. They will also appreciate your modeling for them how to use unfamiliar techniques and materials.

Fourth, let students work together on mathematical assignments and/or quizzes. Even solving in-class exercises with one or two other people provides students with a chance to "think aloud" and to teach and learn from each other.

While there are many elementary teachers who love mathematics and whose enthusiasm is the spark that inspires others to pursue studies in this area, many others are, to put the kindest face on it, negative role models for their students. Many elementary school teachers, most of whom are women, are terrified of mathematics; they feel that a mathematician must be either a genius or a lunatic. Some techniques that may help students become more comfortable with the study and teaching of mathematics follow.

1. The Mathematics Autobiography

Early in the methods course, ask each student to compose a 4 or 5 page autobiographical sketch detailing his or her past experiences in mathematics as a student and the emotional feelings that accompanied these experiences. Ask students to reflect on their feelings and consider the fact that they soon will be teaching mathematics. Students should be assured that their responses will be anonymous.

The purpose of this exercise is to put students in touch with the causes of the anxiety that many feel when dealing with mathematics. Often students who have an "I can't" attitude toward math are reacting to a few powerful negative incidents from their own elementary school years. Sharing with the class a list of common elements found in the autobiographies is a good strategy for eliminating the "I'm the only one who feels this way" syndrome. The following quotations come from autobiographies of students

in an elementary mathematics methods course:

> If (in grade school) problems were missed, you were assigned those same problems to rework; at the same time new material was being introduced. Therefore, you were behind after one assignment... and you easily developed a self-defeating attitude.
>
> I had a problem (in fourth grade) no one was aware of -- I needed glasses and sitting at the back of the room (according to my height) only compounded the problem. When she would use the projector or the blackboard I always got the wrong answer. I felt like a failure -- #1 Dummy.
>
> I felt like a real dummy... I still don't know my measurement facts.
>
> The harder I tried to understand the concepts (in fourth grade math), the more confused I became. To make matters worse, my younger sister, by two years, was a "math whiz".
>
> We had just moved... I was terrified. It (sixth grade) proved to be one of the worst years I can remember. My math teacher was good, but she loved to embarrass us. Our particular class was the low group. She loved to remind us of that over and over again. She would drill us and ridicule us until we did as she expected. I never did.
>
> My fifth grade teacher hated math and she gave hardly any assistance in helping the class understand what we were doing. I can't remember what type of math we did because we did so little.

Statements gleaned from some fifty autobiographies reveal that those conditions which are apt to give rise to feelings of math anxiety are:

a teacher unable to do the work

lack of discipline in the classroom

over-reliance on drill

the use of embarrassment as a motivator

stress on the answer rather than on thought processes

spanking for mistakes in computation

verbal abuse and name-calling when errors are made or papers are not neat

frequent skipping of math time

a teacher too busy to give extra help

rote learning only/no understanding of underlying

lack of opportunity for make-up work after a long absence

Knowing that others have shared similar experiences may not dispel the difficulty, but it may make it easier to decide to do something other than live with these ghosts of the past.

2. Positive Experiences with Math Concepts

Finding a topic which is mathematically interesting, relevant and "new" may seem an impossible task at first glance. At least two topics meet these criteria, however. A study of the Fibonacci sequence (Siu, 1977) and computation in bases other than ten. In the presentation of the mathematics content, the material should be consistently related to concrete examples (in the former case) or concrete objects (in the latter). Students who have searched for examples of the Fibonacci pattern or who have actually counted beans or shells into groups of a specified number will begin to find themselves more at ease with the mathematical concepts inherent in the activities. Having "played" with sequences or place value, students begin to revise their opinion of their mathematical abilities.

3. Positive Experiences with Math Skills

Teachers have always known that practice in mathematics can be made more palatable if it is couched in a game-like situation. Math methods instructions can utilize any of the activities which are found in the professional literature directed to the classroom teacher. These activities serve several purposes - future teachers will not only learn the activity but will also have a chance to experience the student's perception of it. Equally important, they will have the advantage of observing the teacher introduce and conduct an unusual activity.

In addition to relay races, seat games and puzzles, simulation exercises provide a way to use mathematics in a situation which is at once both fun and instructive. One of the best simulation exercises is used in workshops by the Oregon Mathematics Education Council. It takes about 45 minutes to complete and provides computation practice spiced with peer cooperation and competition.

The Pipe Shop

Object: To derive maximum profit

Instructions: You and your partner have on hand twenty 12' steel rods, purchased at a price of 50¢ per foot. You fill orders for rods of lengths from 1 to 10 feet and sell the rods for $1.00 per foot. Each cut you make costs you $1.00. If you have an order you can't fill, it costs you $10.00 for loss of future business. Each order placed will be for 4 rods. Ten orders will be placed, one at a time. After all the orders have been placed, any material remaining may be resold to the company according to this schedule:

1' - 4': no reimbursement
5' - 9': $5 per rod
10' - 12': $10 per rod

Note to leader:

Participants should be paired, each pair is given 20 pieces of graph paper 12 blocks long, a pair of scissors, and two copies of each of three charts. (See Appendix B for a worksheet containing the charts.) Call off the first order for 4 pipes. Participants will need to keep careful records to determine profit (or loss), as each order must be filled before the next order is given. The orders after the first one may be given to each pair as they are ready to proceed. This will avoid rushing some pairs while causing others to wait. You might, for example, have each order on cards within consecutively numbered envelopes. A sample set of orders is shown in Figure 1. Do try this exercise with a group. It provides an astonishing amount of computational practice and fun.

Another vehicle for applying mathematics is to be found in the use of values clarification exercises. One activity designed to clarify individual

	Length									
Order Number	1	2	3	4	5	6	7	8	9	10
1			1		1		1		1	
2	1			1					1	1
3	3							1		
4	1				1		1			1
5						2		1		1
6			2	1						1
7				1				2	1	
8			1	2	1					
9	1		1		1					1
10						1	1	2		

Figure 1: Sample Set of Orders for Pipe-Fitting Simulation

values while students practice computation skills is a values auction. A sample auction worksheet is shown in Appendix B. When the auction is conducted in groups of twelve or less, students have more opportunity to bid on the items. Therefore, the methods instructor may wish to divide the class for this activity. Each student is allowed a certain amount (say $5,000) to spend, and an auctioneer (not necessarily the instructor) is selected to offer each item for bidding. After students have budgeted an amount totaling exactly $5,000 on their copies of the auction list, the bidding begins. As each item is sold each student should record both the sale price and the highest amount that he or she bid.

Many mathematical questions can be examined when the auction has been completed. What item went for the highest price? What was the average amount budgeted for each item? What was the average bid? Was there a trend in top bids as the auctioneer went down the list? What percentage of the class budgeted for each item? Participation in such an exercise is fun, provides a chance for computational practice and teaches a useful classroom strategy.

A Final Word:

As students set out to conquer their own math anxiety, they will, at the same time, be making positive steps in preventing the formation of that attitude in their future students. Their concern for young people should act as a powerful motivator. In order to rid oneself of math anxiety, students will have to face their fears, pinpoint them as specifically as possible, learn the mathematics they are unsure about, and convince themselves that they <u>can</u> do it. At each step, the instructor of a mathematics methods course can help.

For Further Reading

Aiken, Lewis R. Update on attitudes and other affective variables in learning mathematics. Review of Educational Research, 1976, 46, 293-311.

Costello, Charles G. Anxiety and Depression: The Adaptive Emotions. Montreal: McGill-Queens University Press, 1976.

Dreger, Ralph Mason and Lewis R. Aiken, Jr. The identification of number anxiety in a college population. Journal of Educational Psychology, 1957, 48, 344-351.

Dutton, Wilbur H. Attitudes of prospective teachers toward arithmetic. The Elementary School Journal, 1951, 52, 84-90.

Gallwey, W. Timothy and Robert Kriegel. Fear of skiing. Psychology Today, 1977, 11, 78-85.

Gough, Sister Mary Fides. Mathemaphobia: Causes and treatments. Clearing House, 1954, 28, 290-294.

Lazarus, Mitchell. Mathophia: Some personal speculations. National Elementary Principal, 1974, 53, 16-22.

Mitzman, Barry. Seeking a cure for mathephobia. American Education, 1977, 13, 11-14 11-14.

Sime, Mary. The implications of the work of Piaget in the training of students to teach primary mathematics. In A.G. Howson (Ed.) Developments in Mathematics Education. Cambridge: The University Press, 1973.

Simon, Sidney B., Leland W. Howe and Howard Kirschenbaum. Values Clarification. New York: Hart Publishing Company, 1972.

Siu, Man-Keung. Mathematics for math-haters. International Journal of Mathematics Education in Science and Technology, 1977, 8, 17-21.

Spielberger, Charles D. Anxiety: Current Trends in Theory and Research. New York: Academic Press, 1972.

Stent, Angela. Can math anxiety be conquered? Change Report on Teaching, 1977, 9, 40-43.

Suinn, Richard M. and Frank Richardson. Anxiety Management Training. Fort Collins, Colorado: Rocky Mountain Behavioral Science Institute, 1977.

Tobias, Sheila. Math anxiety. Ms. Magazine, 1976, 5, 56-59.

Appendix A

Uncovering Stereotypes in the Classroom

I. For each of the following duties, who is selected:	Boy	Girl	Not Observed
Dusting			
Introducing and assisting visitors			
Cleaning the chalkboard			
Operating equipment (movie projector, etc.)			
Sweeping			
Opening and closing windows			
Carrying heavy objects			
Moving equipment			
Caring for plants			
Caring for pets			
Writing on the board			
Serving on the safety patrol			
Other (specify)			

II. Is the class divided by sex for the following:	Never	Sometimes	Always
Moving through the halls			
Games, relays, spelling bees, etc.			
Physical education			
Committee work			
Eating lunch			
Free play			
Other (specify)			

III. During math class tally the number of children who:

Ask for individual help from the teacher:

Boys _____ Girls _____

Volunteer an answer:

Boys _____ Girls _____

Are called upon to answer or ask a question:

Boys _____ Girls _____

IV. Examine a mathematics text. Count the number of pictures of boys and girls in the first 100 pages.

Boys _____ Girls _____

V. After you have completed the above exercises write a conclusion or summary here.

Appendix B

Pipe Shop Simulation Worksheet

Sales Record

	Lengths Desired									
Order No.	1'	2'	3'	4'	5'	6'	7'	8'	9'	10'
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Inventory List

	Lengths of Remaining Rods											
Order No.	12'	11'	10'	9'	8'	7'	6'	5'	4'	3'	2'	1'
0												
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

Running Expenses and Income

Order No.	$ Lost on costs	Money from sale	Money made
0	Spent $120 to buy rods		
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Appendix C

Values Auction Worksheet

	Amount I Budgeted	Highest Amt. I Bid	Top Bid?
A satisfying and fulfilling marriage			
Freedom to do what you want			
A chance to direct the destinies of a nation			
The love and admiration of friends			
Travel and tickets to any cultural or athletic event as often as you wish			
Complete self-confidence with a positive outlook on life			
A happy family relationship			
Recognition as the most attractive person in the world			
A long life free of illness			
A complete library for your private use			
A satisfying religious faith			
A month's vacation with nothing to do but enjoy yourself			
Lifetime financial security			
A lovely home in a beautiful setting			
A world without prejudice			
A chance to eliminate sickness and proverty			
International fame and popularity			
An understanding of the meaning of life			
A world without graft, lying or cheating			
Freedom within your work setting			
A really good love relationship			
Success in your chosen profession			